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ABSTRACT

This paper, presented at the 1978 meeting of the National Association for Research in Science Teaching, describes the development of a resource for the identification of science process skills in young children (grades 4-7). The Test of Science Processes (TOSP) of Tannenbaum was modified for presentation in a broadcast instructional television format by reducing the number of items using judges' opinions and item analysis data, and reducing the reading level of test questions. It is concluded that the Television Test of Science Processes (TTSP) provides elementary science teachers and administrators with a useful test of science processes that can be used for assessing science competencies in young children. (HM)

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DEVELOPMENT AND VALIDATION OF A TELEVISED TEST OF SCIENCE PROCESSES

A Paper Presented at the Fifty-first National Convention

of the

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DEVELOPMENT AND VALIDATION OF A TELEVISED TEST OF SCIENCE PROCESSES

BACKGROUND

The Television Test of Science Processes was developed as a part of a larger, on-going project. In 1968, the Pennsylvania Department of Education (PDE) embarked on a statewide thrust to assist elementary teachers in a transition into some of the newer methods of teaching science. This effort was called Science for the Seventies. In 1972, The Pennsylvania State University and PDE devised a system for using instructional television as a major resource in the dissemination and implementation of Science for the Seventies (SFTS) for elementary school classrooms throughout Pennsylvania. (Shrigley, Alfke, Szabo, and Welliver, 1975) It encompasses a teacher's guide which deals with the pedagogy of contemporary elementary science education, a set of primary and intermediate grade science lessons, ten 15-minute televised programs for use with primary grade students, ten 20-minute televised programs for use with intermediate level students, and five in-service televised programs to help teachers use SFTS-ITV Handbook for Teachers which provides an orientation and instructions in the use of the resource (PDE, 1975).

SFTS has several functions: one, it could be the model around which a school district could build, over the years, a K-6 inquiry-type science curriculum. This would mean adding many lesson components to the 25 published by PDE; two, SFTS could be the inquiry component to a conceptually oriented science curriculum. Teachers could pick and choose those lessons that reinforce an already established curriculum; three, the tapes and accompanying lesson could provide a four month "springboard" to science for new primary or intermediate teachers; and four, in that the philosophy of SFTS is compatible with such inquiry programs as SCIS, ESS, and S-APA, SFTS could serve as either a bridge or a supplement to any of the three programs mentioned.

Collateral with the televised instruction, the Science for the Seventies project constructed and field tested a television test to assess the impact of the instructional material (Torrence, 1976). The data presented here represents the beginning effort to provide reliability and validity information on the Television Test of Science Processes.

OBJECTIVES

One of the stated objectives of this statewide ITV resource emphasizes science processes:

> Following the broadcasting of SFTS oriented television lessons, children in participating classrooms will exhibit a measurably significant increase in their facility in the use of science processes. (SFTS Phase 1 Project Report, 1974, p. 21)

Relative to the above terminal performance objective, a tentative projected performance measure was drafted:

> A televised test will reveal increased student competency in the use of science processes and attainment of aims and objectives of SFTS. (SFTS Phase 1 Project Report, 1974, p. 24)

Once the decision to use a test of science processes to gather data about intermediate grade school children in Pennsylvania was made by members of the Science for the Seventies Committee, several tests were investigated for possible use. No test reviewed possessed the combined requirements of being valid for use by intermediate level students and for use via the television medium. However, of the available tests purporting to measure science processes, the Test of Science Processes (Tannenbaum, 1968) was judged to be adaptable for intermediate grade use because it was an instrument at least possessing content validity. Also the processes categorized as subtests by the author encompassed most of the processes listed by science educators. Most applicable to the SFTS objectives was its visual presentation mode which had implication for the television format. A television format has the advantage of providing repetition, clarification, and motion cues to the questioning procedure. There were two reasons why the Test of Science Processes in its original form was not appropriate for use as the assessment instrument for the SFTS: (1) the test was designed for junior high school level, and (2) it was designed for 2x2 35mm slide presentation.

Because television is a major component of the SFTS resource, it was logical for a test to be produced in the same medium. A television test would compliment the total SFTS television package, would provide a free testing resource to teachers and administrators, and would provide uniformity in test administration. Television provides the least expensive delivery system for the presentation of the visuals required in the testing situation.

This posed two problems and formed the basis of this study. First, could the Test of Science Processes be modified for use by intermediate level students; and second, could the TSP be adapted for use through the medium of television? The adaptation of an existing instrument involved a replication of the steps used to create the initial instrument as well as the addition of several new steps unique to the production of the second instrument. These steps were to derive content validity, to produce the print and non-print components, to establish the reliability through item analysis, to empirically validate and to establish norms.

THEORETICAL RATIONALE

A review of the literature found considerable support for the need to teach those skills and abilities employed by scientists and identified by psychologists and educators as science processes. However, no general agreement in the list of those skills and abilities was found. This imprecision was canoted in the Dictionary of Education which lists this open-ended definition:

> Process approach, an approach to science instruction in which children learn generalizable process skills that are behaviorally specific but which carry the promise of broad transferability across many subject matters; it adopts the idea that novel thought can be encouraged in relation to each of the processes of science, such as observation, inferrence, communication, measurement, etc. (Good, 1973, p. 439)

This ambiguity of terminology portends difficulty to the test developer who attempts to measure science processes. If no uniformity exists, the test developer must define those characteristics to be assessed by his unique instrument. This could result in a proliferation of instruments which measure unique factors wholly different from other instruments but are collectively labelled science process tests. Table 1 is a summary of those processes applicable to selected educators, educational psychologists, and science curricula.

Several tests have been developed to assess the acquisition of those skills and abilities collectively described as science process. Some of the tests are the S-APA (Science -- A Process Approach), Science Process Instrument (SPI), American Association for the Advancement of Science, 1970; the Processes of Science Test, Biological Science Curriculum Study, 1962; The Science Process Test (TSPT), Ludeman, 1974; the Science Observation and Comparison Test (SOCT), Hungerford and Miles, 1969; the Science Test for Evaluation of Process Skills (STEPS), Morgan, 1971; the Test of Science Processes (TSP), Tannenbaum, 1968; and the science test of the Comprehensive Tests of Basic Skills (CTBS), McGraw-Hill, 1973.

Each of these tests is designed for varying grade levels, ranging from fourth to twelfth grade. None of the tests is for television presentation.

The literature revealed a scarcity of testing via television. Of the studies reporting on television testing, most have concluded that television presentation of tests has several advantages over traditional modes of testing. The literature suggested that testing could be effectively conducted through the medium of television.

TABLE I

PROCESSES APPLICABLE TO SELECTED EDUCATORS, EDUCATIONAL PSYCHOLOGISTS, AND SCIENCE CURRICULA

Processes	Tannenbaum	AAAS	Shamos (COPES)	Jevons	Gagne	Curtis	Atkin	Conant	SCIS	ESS	Kessen	Keeslar
observing	X	X	X	X	X	X			X		X	
comparing	X		X						X		X	
classifying	X	X	X	X	X				X		X	
quantifying	X				X							
measuring	X	X	X	X					X		X	
experimenting	X		X	X							X	X
inferring	X	X		X	X							X
predicting	X	X	X	X					X			
communicating		X				X						
recognizing and using time space relationships	X											
interpreting		X						X				
evaluating		X									X	X
discriminating		X										X
describing		X		X								
identifying and differentiating			X									X

TABLE I (cont'd)

Processes	Tannenbaum	AAAS	Shamos (COPES)	Jevons	Gagne	Curtis	Atkin	Conant	SCIS	ESS	Kessen	Keeslar
inducing and deducing			X									
hypothesizing			X								X	X
orienting				X								
making conceptual models				X								
reasoning					X							
drawing conclusions											X	X
recognizing and using numbers and number relationships		X										

METHODOLOGY

The procedure for modifying the Test of Science Processes (TSP), and adapting it for television required the following steps: (1) present the question content of the TSP to a panel of judges on elementary science curriculum and instruction to ascertain the content validity of the test as applicable to intermediate level students, (2) rewrite those questions recognized appropriate by the experts to conform to the readability adequate for upper elementary students, (3) produce a pilot test composed of the adapted questions on quadraplex video tape and produce the associated print materials, (4) provide a pilot exposure and techniques to ascertain appropriate test item exposure time, (5) edit the video production to conform to the time data, (6) provide a pilot run of the televised test to a large number of students to amass data for item analysis, (7) establish statistical parameters by which the item analysis would provide a refinement of those questions which would comprise the final form of the test and edit the video production accordingly, (8) provide for broad exposure of the test to ascertain norms for target populations; and (9) provide an experimental study to amass concurrent and predictive validity data. The following is a summary of those activities that were necessary to complete the study.

An item pool was generated from the ninety-six items of the Test of Science Processes which were a representative sample of the eight science processes identified and defined by Tannenbaum and applicable for the intermediate level with minor revision. These questions were chosen on the basis of their requiring the skills and abilities recognized as process skills and on the basis of their applicability to intermediate level students. The question selection was performed by a panel of elementary science educators of The Pennsylvania State University whose credentials reflect a high degree of experience in research and teaching and are recognized both nationally and internationally as possessing a high degree of expertise by the academic community.

After the item pool was identified, an implementation procedure was pursued to produce the print and non-print components to form a prototype Television Test of Science Processes. The print component consisted of a television test booklet and teacher's manual. It involved a careful review of the verbal component, the visual digital information, modification of the test items' vocabulary and syntax to conform to a readability level applicable to the intermediate level. The modified verbal message was subjected to two readability measures to ascertain its appropriateness for the target population. This was performed and the resultant study found both vocabulary and syntax to be appropriate. Question answers and distractors were scrambled in a random manner using a table of random numbers for answer replacement. Upon completion of the total print message, it was organized and printed in the format of the Test of Science Processes.

The non-print component was reviewed and organized in a television script into the audio and visual modes. It was decided that the narration of the questions and the answers were too time consuming and were distracting. The visual information was reviewed for optimal television presentation. For clarity of visuals, implementation of motion where appropriate, cost considerations, and production techniques, it was decided to record all visual information on two-inch video tape of broadcast quality. Using the production studio of WPSX, the entire verbal and visual information was produced. After an introduction and directions for taking the test, the question visuals and question narration preceded by the appropriate number were recorded for each of the sixty-eight questions of the identified item pool. From the end of the narration to the next item, visuals were shown for ninety seconds. This video tape package combined with the print component formed Form A of the Television Test of Science Processes, the prototype of research instrument for further study.

To ascertain the appropriate timing for each of the visuals, Form A of the TTSP was subjected to an item response time study. A population of central Pennsylvania fifth grade students were identified and given Form A of the instrument. Graduate students of The Pennsylvania State University recorded the times for each student to respond to each question inclusive of corrections. Using the rule of the 90th percentile, a cutting time was identified for each question. The video tape was edited to conform to the appropriate times. The edited tape became Form B of the test instrument.

Plan for a pilot exposure of Form B to a large population of intermediate level students to derive item analysis data was facilitated through contacts made with the Pennsylvania Department of Education. The instrument was piloted in a large suburban Philadelphia school system using closed-circuit television. Data was amassed on a large population and, using established guidelines for accepting or rejecting items on the basis of point biserial correlations and difficulty, forty items were identified for inclusion into From C of the Television Test of Science Processes. Revision of the entire print and non-print component was effected to conform to the item analysis data. The print material was revised and new booklets printed. A major edit of the video tape was conducted to renumber all appropriate remaining questions, to include appropriate credits, and to conform to the time limits of two 30-minute programs required for public broadcasting.

Public broadcasting over the service area of the Allegheny Educational Broadcast Council of Pennsylvania provided massive exposure and the gathering of a large data fund for a norming study. Test results from fifth grade students from nineteen school systems of varying profiles were processed and tabulated into percentiles and T-scores and plotted into a frequency distribution.

A study to determine validity was initiated. In conjunction with a large central Pennsylvania school system, data were gathered from a large population of students on a variety of variables. The students were given the TTSP, TSPT, The Science Test of the CTBS over a span of one year. This and other data were collected within safeguards of confidentiality and recorded on EDP cards. Information on fifteen variables were processed using the Pearson product-moment correlation and factor analysis programs.

DATA SOURCES

There were three phases or forms of the present TTSP. The first form (TTSP - Form A) of the TTSP included 68 items judged by experts to be content valid for Science for the Seventies assessment at the fifth and sixth grade levels. These were selected and revised from Tannenbaum's original 96 items.

The television production consisted of directly videotaping the visuals (stimulus cues for test items) rather than to use the 2 x 2 slides through the TV multiplexer system. TTSP - Form A was taped with script allowing 90 seconds response time for each of the 68 items. TTSP - Form B was produced after actual item response time data were gathered on a sample of fifth grade students using TTSP - Form A. Response time allowances on Form B ranged from 16 to 58 seconds and were based on 90th percentile values of time actually taken, per item, during Form A administration. TTSP - Form B was then field tested with both fifth and sixth grade students. From Form B field testing, using criteria of item difficulty ranging from .35 to .85 and positive item - total test score point biserial correlations, a final 40 item TTSP - Form C was produced. This new videotape and auxillary test administration procedure materials were used in the norming reliability and validation data gathering phase of the TTSP project.

The sample in the large norming reliability study using Form C of the TTSP consisted of 3480 fifth grade students in Pennsylvania drawn from 12 different counties and 19 different school systems. Both public and Catholic, and rural and urban schools were included in the sampling plan. The initial validation data were collected on an additional sample of 207 fifth and sixth grade students.

During October, 1975 the fifth grade norming sample was given the TTSP - Form C under normal classroom conditions of television viewing and test taking. Administration is accomplished in two one-half hour program tapes. Broadcast was done over WPSX-TV, Channel 3 of the Pennsylvania Public Television Network in cooperation with the Allegheny Educational Broadcast Council. Only basic TTSP - Form C data were collected from this norming sample.

For the validation sample of fifth and sixth grade students, the following information was collected: Television Test of Science Processes (TTSP) scores; Test of Science Processes (TSP) scores from Tannenbaum's test; language total and subtest scores for the Comprehensive Test of Basic Skills (CTBS) from McGraw-Hill, 1973 including areas of science, math, vocabulary, reading comprehension and social studies; total scores and verbal and non-verbal subtest scores on the Short Form Test of Academic Aptitude (SFTAA) by McGraw-Hill, 1970; and science grades (0-4 scale) on midyear report cards. Correlations of variables with science grades should be viewed essentially as predictive validity coefficients whereas inter-correlations of the test variables should be viewed as concurrent validity coefficients.

FINDINGS

Reliability was determined through internal consistency analysis using the Kuder-Richardson formula 20. Internal consistency coefficients indicate the extent to which items hang together as a unidimensional scale. For the norming sample of 3480 fifth grade students, the KR_{20} value was .736. Approximately 74% of the observed score variance is estimated to be true score variance. For the validity sample comprised of both fifth and sixth grade students, the KR_{20} value was .816. This larger coefficient can probably be attributed to the greater variability of performance (standard deviation = 6.29 in validity sample versus 5.35 in norming sample) on the TTSP - Form C. It should be noted that Tannenbaum's (1968) cited TSP reliability based on a 96 item length scale was .91. For the present data, if the reliability coefficients for both the norming and validity samples are adjusted via the Spearman-Brown formula for a test length factor of 2.4 (40 items to 96 items), the new estimates of KR_{20} values would be .87 and .914 respectively. Hence, the reliability of the TTSP - Form C seems, relative to length, comparable to Tannenbaum's original scale.

Table 4 presents the results of correlating each test variable with midyear science grades. All correlations are significantly different than 0 at the .01 level. The best single prediction of grades was Tannenbaum's TSP and the lowest correlation resulted between grades and the new TTSP. However, all correlations are in the moderate range. Variance common to each predictor with the criterion of grades ranged from 32% to 48%. Table 1 also presents the intercorrelations amongst the test variables. Again, all correlations are significantly different than 0. While the TTSP consistently has somewhat lower intercorrelations, it seems obvious that a strong common core runs through all measures. Within the guidelines established for a statement of criterion-related validity, it was found that the Television Test of Science Processes - Form C was moderately to highly correlated with The Science Process Test and the Science Test of the Comprehensive Test of Basic Skills.

TABLE 2

STATISTICS FOR THE NORMING SAMPLE ON THE TTSP, FORM C

Grade level	5
Number of students	3480
Mean score	15.96
Standard deviation	5.35
Standard error of measurement	2.75
Mean point biserial	0.294
KR-20 reliability	0.736
Mean difficulty	0.399
Test range	.38
Standard error of test mean	0.09
Skewness	0.39
Kurtosis	3.21

TABLE 3

STATISTICS FOR THE VALIDITY SAMPLE ON THE TTSP, FORM C

Grade level	5
Number of students	203
Mean score	18.86
Standard deviation	6.29
Standard error of measurement	3.03
Mean point biserial	0.352
KR-20 reliability	0.816
Mean difficulty	0.497
Test range	29
Standard error of test mean	0.44
Skewness	0.31
Kurtosis	2.38

TABLE 4

Intercorrelations of Variables (N=207)

1.	TTSP	1.000	.658	.620	.611	.645	.660	.653	.634	.641	.552	.626	.570
2.	TSP		1.000	.779	.749	.737	.761	.770	.783	.813	.770	.720	.690
3.	CTBS-Voc.			1.000	.850	.822	.775	.753	.819	.842	.864	.653	.646
4.	CTBS. Read C.				1.000	.800	.783	.746	.805	.800	.801	.643	.610
5.	CTBS - La. Tot.					1.000	.737	.792	.791	.796	.774	.665	.642
6.	CTBS - Sci.						1.000	.764	.773	.813	.755	.723	.603
7.	CTBS - Math							1.000	.768	.812	.710	.789	.681
8.	CTBS - Soc S.								1.000	.831	.791	.720	.630
9.	SFTAA - Tot									1.000	.929	.888	.669
0.	SFTAA - V										1.000	.664	.593
1.	SFTAA - NV											1.000	.650
2.	GRADES												1.000

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EDUCATIONAL SIGNIFICANCE

The new Television Test of Science Processes has comparable internal consistency reliability to its parent instrument - Tannenbaum's Test of Science Processes. Validity data - both predictive and concurrent - indicates that the TTSP is comparable in predicting fifth and sixth grade science grades and also measures essentially the same characteristics as the other validation instruments.

The Television Test of Science Processes (TTSP), relative to the Science for the Seventies ITV resource, has several potential benefits: (1) provide pretest entry data in an empirical study to measure the effectiveness of SFTS exposure, (2) survey general student normative performance on science processes on a statewide scale, and (3) offer an additional evaluative instrument to assess mastery of science processes.

In a more general sense, production and validation of the TTSP provides a useful addition to the small number of tests of science processes available to educators. The instrument is unique in its televised modality. It should be a valuable resource for elementary science teachers and administrators, researchers in elementary science education, instructional developers working with television projects in elementary science, and should provide a valuable source of data for continuing research in elementary science, process testing, and television testing.

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